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ABSTRACT

This study was concerned with children's ability to conserve spatial relationships among objects in different arrangements, in the presence of projected changes in the observer's visual field. The objectives were: (1) to determine the effects of varying types of arrangement and number of objects in the arrangement on perspective ability performance, (2) to investigate the relationship of age and sex to the acquisition and performance of perspective coordination, and (3) to compare the difficulty level of left-right, foreground-background relations. Ten boys and ten girls each from kindergarten, third, and sixth grades (N=60) were randomly selected from pupils having an IQ within the 83 to 117 range. The measure was an adaptation of Piaget's three-mountain coordination of perspective task. While viewing six different object arrangements from a static position, subjects were asked to match photographs of the object groups with the position of the camera when the picture was taken. The document provides results regarding (1) object number and arrangement effects of task difficulty, (2) the effect of masking factors on performance levels, and (3) conclusions about sex and age in relation to performance. (Author/AJ)

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THE EFFECT OF VARYING OBJECT NUMBER AND TYPE OF ARRANGEMENT ON CHILDREN'S ABILITY TO COORDINATE PERSPECTIVES[1]

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In recent years there has been a growing interest in the development of spatial operations in children and the effect of such operations on their general intellectual functioning (Sherman, 1967). There is also an increasing awareness of the importance of spatial concepts as they relate to particular academic content, such as mathematics and social studies.

In spite of this mounting concern there is a dearth of research dealing with identification of normal patterns of children's spatial conceptualization other than the early comprehensive work of Piaget, whose theorizing and research on children's spatial concepts are found in The Child's Conception of Space (1967), first published in France in 1948. If Piaget's findings on the child's development of spatial concepts continue to be supported in replications across time and cultural groups, then educators need to take notice and consider re-evaluating present educational practices in the light of these data. But before this can be done, there is need to increase the amount of information available concerning the natural development of spatial ability. It also is important that more rigorous and systematic follow-up studies

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be conducted to examine the psychological processes involved in performing such Piagetian tasks as coordination of perspectives--the focus of the present study.

This study was concerned primarily with children's ability to conserve spatial relationships among objects in different arrangements, in the presence of projected changes in the observer's visual field. The key to this ability to coordinate perspectives is mastery of spatial relativity: the concept that left-right, above-below, and foreground-background relationships are not static, but vary with changes in the observer's viewpoint.

Michael, Guilford, Fruchter, and Zimmerman (1957) reviewed studies of primary spatial abilities and proposed a three-factor spatial-visualization domain consisting of a spatial relation and orientation factor, a visualization factor, and a kinesthetic imagery factor. The basic psychological process associated with the spatial relations and orientation factor is the ability to comprehend the nature of the arrangement of elements within a visual stimulus pattern, primarily with the observer's body as the frame of reference. Visualization involves the ability to mentally rotate or move parts of an object or configuration according to relatively explicit directions and to recognize the new position of the modified objects. The highly tentative kinesthetic factor represents a left-right discrimination with respect to the location of the subject's body.

As the present study indicates the coordination-of-perspective task seems to be primarily a spatial relations and orientation task, since the key factor in relating objects to a viewer's visual field is

mastery of the concept that spatial relations (left-right, etc.) vary with changes in the observer's viewpoint. The task apparently necessitates that the observer project himself into an imagined position and determine direction relative to that location. This requires the observer to use his own body as a frame of reference in characterizing the spatial relations existing among the objects in the stimulus arrangement.

Besides attempts to isolate spatial abilities by factor analysis, a major research effort has been made to trace the pattern of development in children's changing conceptualization of space. The most comprehensive work in this area is that of Jean Piaget (1967) who, in his experiments dealing with perspective operations, traced the developmental stages found in 100 children from 4 to 12 years of age. The task situation involved a pasteboard model of a landscape with three mountains placed in a triangular arrangement. While viewing the model, the child was first asked to identify the positions from which a series of photographs of the mountains had been taken. The child also was required to arrange replicas of the mountains as seen from a given perspective. Finally, a doll was moved from place to place around the mountains and the child, using cutouts of the mountains, was asked to reconstruct by inference the changes in perspective that would accompany the doll's movements.

Piaget found that not until an average age of about 8 years did the children vary spatial relationships with changes in observer positions. Before this age, the children tended to pick their own

viewpoint as the correct one regardless of the change in the observer's viewpoint. Not until after age 9 could the children systematically deal with the spatial relationships involved in coordination of perspectives.

Recently, a number of investigators (Elliot 1966, Miller 1967, Dodwell 1968, and Towler 1969) have used variations of Piaget's map test to gain additional data on children's acquisition of perspective ability. Most of these studies used nonrectilinear, multiple-object arrangements, where the number of objects used and the type of arrangement remained unchanged.

While these studies yield data regarding the young child's ability to coordinate perspectives in rather complex situations, they do not demonstrate how children handle perspectives in situations requiring only rudimentary ability to coordinate left-right, foreground-background relationships. The present study attempted to do this by investigating how children from a fairly wide age range coordinate perspectives in situations using object arrangements of varying complexity.

More specifically, the major objectives of this study were: (1) to determine the effects of varying type of arrangement and number of objects in the arrangement on perspective ability performance, (2) to investigate the relationship of age and sex to the acquisition and performance of perspective coordination, and (3) to compare the difficulty level of left-right, foreground-background relations.

Hypotheses

It was hypothesized that:

1. Performance scores would increase as the number of objects in the arrangement decreased.

2. Arrangements with rectilinear arrays would be significantly easier to coordinate than arrangements with nonrectilinear arrays.

3. Foreground-background relations would be easier to coordinate than left-right relations.

4. The masking of objects by other objects would make coordination of perspectives easier.

5. In the one-object arrangements the front and back views would be significantly easier to coordinate than the side and three-quarter views.

6. Boys would have higher performance scores than girls.

7. Performance scores would increase as a function of an increase in the subject's age.

Method

Subjects

Subjects were 60 children from a Murfreesboro, Tennessee public school. Ten boys and ten girls in kindergarten, third, and sixth grades were randomly selected from pupils having an IQ within the 83 to 117 range.

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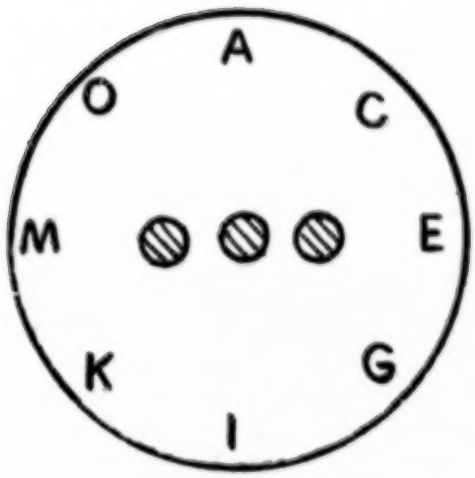
Instrument and Procedure

The measure used was an adaptation of Piaget's three-mountain coordination of perspective task. While viewing six different object arrangements from a static position, subjects were asked to match photographs of the object groups with the position of the camera when the picture was taken.

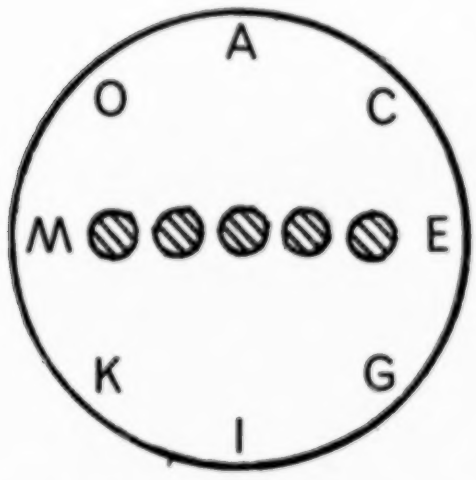
The object arrangements varied along two dimensions--number of objects in the group (1, 3, 5) and type of arrangement (rectilinear and nonrectilinear). The single-object arrangements each used four toys (airplane, doll, truck, and telephone), presented one at a time with two response positions each. The response positions included the front, back, side, and three-quarter view of each toy. The multiple-object arrangements shown in Figure 1, used blocks of different colors and shapes with no discernable front, back, or sides (so the correct position could not be determined by one object alone).

The eight response positions of each arrangement were marked by 16 one-half inch letters evenly placed around the outer edge of a circular base. The subject's position was at a point mid-way between response choices K and I.

The photographs of the object arrangements were taken with a single lens reflex camera placed 20 inches from the center of the circular base upon which the objects were placed. The angle formed by a line from the center of the disk to the camera lens was approximately



Arrangement R-3



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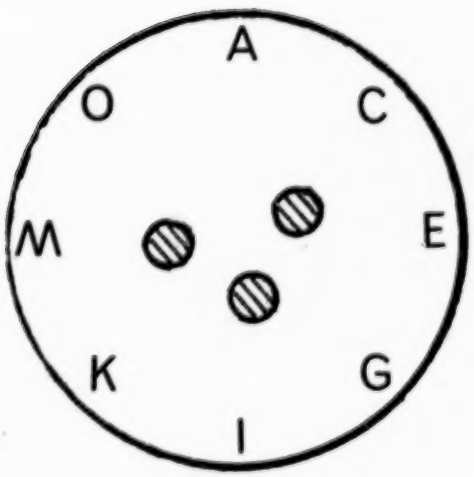
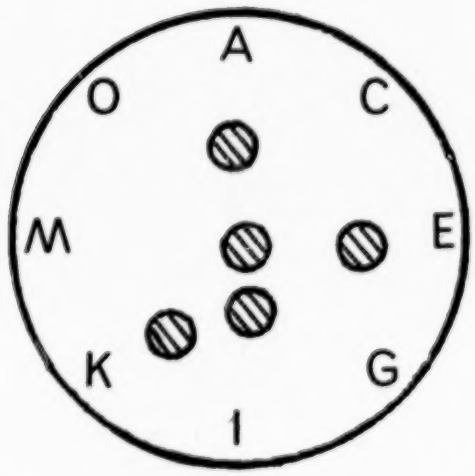


Arrangement NR-3



Arrangement NR-5

Figure 1. The multiple-object arrangements.

20 degrees. When the instrument was administered, an attempt was made to have the subject seated with his eyes about 20 inches from the center of the disk and at about the same angle of regard as the camera. The angle of regard was adjusted by raising or lowering the object disk until it was approximately 7½ inches below the subject's eye level. No elaborate controls were used to see that the subject's position regarding these two variables was exact, since this might have interfered with the informal, game-type approach used in administering the test. The color photographs used in the study were 5 by 3½ inches in size. They were encased in clear plastic to protect them from damage.

The six arrangements were presented at one sitting with an average administration time of approximately 20 minutes. The arrangements were presented to each subject individually in a random order and sequence. The sequences were drawn from a table of random numbers and assigned randomly to the 60 subjects (Lindquist, 1953). The single-object arrangements were presented together since these arrangements used the same four toys and administration was greatly simplified by presenting all of the items for each toy at one time. The order of individual item presentation within each arrangement was determined by simply shuffling the eight pictures before each new test administration.

Scoring

Items were scored according to the degree of accuracy of the response. Scores for each item ranged from 8 points for a response which was exactly correct to 0 points for a response representing an error of 180 degrees. The total possible points for each item was 8, for each

arrangement 64, and for the total six arrangements 384.

Analysis of the Data

The basic design used in this study was a three factorial analysis of variance with repeated measures on one factor (Lindquist, 1953). Age and sex factors remained the same for each analysis, while the arrangement factor varied according to the hypothesis being tested. The analysis of variance used the following arrangement or item groupings on the repeated measures dimension: (a) rectilinear and nonrectilinear arrangements; (b) simple (F,B) and complex (S3-Q) views of the one-object arrangements; (c) each individual arrangement; (d) left-right, foreground-background, and combination left-right, foreground-background relations; (e) views with no masking, views with one masked object, and views with two masked objects; and (f) number of objects.

Further investigation of significant interactions or multiple comparisons utilized simple analysis of variance and *t* tests, adjusted for multiple comparisons through use of the Newman-Keuls procedure.

Results

It was hypothesized that it would become more difficult to coordinate perspectives as the number of objects in the arrangement increased from 1, to 3, to 5. Results showed that while the one-object arrangements were significantly easier than either the three- and five-object arrangements, there were no significant differences between the three- and five-object arrangements. Indeed, as can be seen in Table 1,

mean performance scores on the five-object arrangements were slightly higher than mean scores on the three-object arrangements.

Table 1

Mean Scores on the One-, Three-, and Five-Object Sets

		Number of Objects			
		1	3	5	Total
Age	5	98.3	69.5	74.0	80.4
	8	97.3	88.0	91.5	92.2
	11	98.2	98.4	95.1	97.2
	Total	97.9	85.3	86.7	*
Sex	Girls	94.3	83.1	85.2	87.5
	Boys	101.5	87.5	88.2	92.5

It was hypothesized that the rectilinear arrays would be easier to coordinate than the nonrectilinear arrays. Analysis of the data revealed that this difference did not appear. Instead, the rectilinear arrays proved to be significantly harder to deal with than the nonrectilinear arrays.

Performance level seemed to have been determined by the presence or absence of left-right and object-masking factors found in particular

views rather than by the task variables examined. Significantly lower performance scores (.01) were associated with views requiring left-right discriminations than with views requiring foreground-background discriminations. Views with two masked objects had significantly higher performance scores (.01) than both views with no masking and views with only one masked object.

The front and back views of the single object arrangements produced significantly higher performance scores (.01) than the side and three-quarter views. The side views were also significantly easier to coordinate than the three-quarter views.

No significant sex differences in performance were found. On four of the six analyses, however, there was a noticeable but nonsignificant age by sex interaction. Girls tended to perform slightly better than boys at the youngest age level, while boys tended to perform somewhat better than girls at the oldest age level.

There were significant age differences in performance on four of the six analyses, with significant age by test interactions on two of these four. The interaction arose from the fact that on the multiple-object arrangements, but not on the single-object arrangements, there was a significant increase in performance scores with an increase in age.

On three of the four arrangements with significant age differences there were nonsignificant differences on scores of the middle and oldest age groups. This leveling effect also was found on one of the

two significant age difference in the other analyses. All other differences in performance between age levels were significant. The greatest difference in performance on most of the arrangements and item categories occurred between age levels 5 and 8.

Discussion

Since both the number of objects used and the type of arrangement had no measurable effect on the difficulty level of the coordination of perspective task, it is necessary to look elsewhere for an explanation of the difficulty levels found among the various arrangements. Although not anticipated at the start of the study, the data strongly suggest that the highly significant differences found between types of items (L-R, M-1, etc.) rather than types of arrangements provide the most adequate explanation of the performance differences found among the six arrangements.

As hypothesized, items across arrangements which required a left-right discrimination, including the side and three-quarter views of arrangement S3-Q-1 and the views with no masking from arrangements NR-3 and NR-5, proved to be significantly harder to coordinate than items in which no left-right discrimination was needed. Examination of Table 2 shows the breakdown of left-right, no left-right items for each arrangement.

Table 2

Arrangement Order of Difficulty and Item Types

Order of Difficulty	Type and Number of Relations	
	Left-Right	No Left-Right
FB-1*	0	8
NR-5*	1	7
NR-3	4	4
S3-Q-1	8	0
R-3	6	2
R-5	6	2

*There were significant differences between scores on arrangement FB-1 and all other arrangements and between scores on arrangement NR-5 and R-5, R-3. All other performance differences were nonsignificant.

Since there were no significant differences in performance among the last four arrangements in the list, results indicate that it was the presence or absence of left-right items within an arrangement that determined the difficulty level of the arrangement as a whole.

These findings support the view discussed by Towler (1969), that ability to handle left-right orienting responses is vital to success in coordinating perspectives. Although it is possible that the perspective ability task used in this study could be a visualization measure as defined by Michael (1957), results indicate that spatial relation and orientation abilities are the key factors in determining successful performance on the task. This conclusion is advanced

because of the fact that significant differences in performance appeared among types of test items across all the object arrangements rather than among the arrangements themselves. Seemingly this would not have been true if the subjects were using a dynamic visualization process to mentally rotate the total object arrangement until their mental image matched the stimulus configuration found in the photograph. Such a mental rotation process would have been expected to produce differences in performance with changes in arrangement complexity. Such differences from arrangement to arrangement were not found in this study. Rather, it was the characteristics of certain views within each arrangement which resulted in performance differences. This indicates use of an orientation process combined with a type of static imagery, rather than the dynamic imagery characteristic of a visualization process.

While results demonstrated that left-right discrimination situations greatly increase the difficulty of coordinating viewpoints, they do not provide information as to why this is so. The investigator suggests that the difficulty of coordinating viewpoints is a function of the number of factors in the situation which must be simultaneously related. If the viewer verbally characterizes the spatial relationships existing among the objects by determining their position in relation to a line projected from the viewer to the back central portion of the field, then viewpoints in which there is no overlapping of objects would require the use of left-right concepts. This situation requires the simultaneous positioning of all the objects on a left-right dimension as opposed to views where objects overlap, thus requiring the foreground-background positioning of only two overlapping objects. Further research is needed on this problem to determine the specific strategies used by subjects in coordinating different types of perspective views.

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